Continued Development of Meandering Winding Magnetometer (MWM®) Eddy Current Sensors for the Health Monitoring, Modeling and Damage Detection of Composite Overwrapped Pressure Vessels (COPVs)

Richard Russell (NASA KSC), Russell Wincheski (NASA LaRC), Dr. David Jablonski, Dr. Andy Washabaugh, Dr. Yanko Sheiretov, Mr. Christopher Martin and Dr. Neil Goldfine (JENTEK Sensors)

Abstract

Composite Overwrapped Pressure Vessels (COPVs) are used in essentially all NASA spacecraft, launch vehicles and payloads to contain high-pressure fluids for propulsion, life support systems and science experiments. Failure of any COPV either in flight or during ground processing would result in catastrophic damage to the spacecraft or payload, and could lead to loss of life. Therefore, NASA continues to investigate new methods to non-destructively inspect (NDE) COPVs for structural anomalies and to provide a means for in-situ structural health monitoring (SHM) during operational service.

Partnering with JENTEK Sensors, engineers at NASA, Kennedy Space Center have successfully conducted a proof-of-concept study to develop Meandering Winding Magnetometer (MWM) eddy current sensors designed to make direct measurements of the stresses of the internal layers of a carbon fiber composite wrapped COPV. During this study three different MWM sensors were tested at three orientations to demonstrate the ability of the technology to measure stresses at various fiber orientations and depths. These results showed good correlation with actual surface strain gage measurements.

MWM-Array technology for scanning COPVs can reliably be used to image and detect mechanical damage. To validate this conclusion, several COPVs were scanned to obtain a baseline, and then each COPV was impacted at varying energy levels and then rescanned. The baseline subtracted images were used to demonstrate damage detection. These scans were performed with two different MWM-Arrays with different geometries for near-surface and deeper penetration imaging at multiple frequencies and in multiple orientations of the linear MWM drive.

This presentation will include a review of micromechanical models that relate measured sensor responses to composite material constituent properties, validated by the proof of concept study, as the basis for SHM and NDE data analysis as well as potential improvements including design changes to miniaturize and make the sensors durable in the vacuum of space.